PTI Observations of 89 Her

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Abstract

We report on observations of the star 89 Her using the Palomar Testbed Interferometer (PTI). Our observations in the H and K band suggest the presence of a circumstellar dust shell. We discuss to observations in the context of simple models for 89 Her.

1 Introduction

The star 89 Her is an extensively studied post-AGB supergiant with a large infrared excess and a radial velocity signature indicative of a low mass companion. As this star is thought to be undergoing mass loss and is sufficiently bright, it was selected as a candidate for PTI observations with the hope of detecting the warmer component of the circumstellar material. The PTI observations do show very unusual behavior of the V^2 estimator; they imply the diameter of the object is increases substantially (~ 2) between the H and K bands. Although there are some differences in the published values for parameters of the system, we have used the values below for the purpose of interpreting our interferometer data.

2 Background

- F2 Ibe - post AGB (due to dust shell)
- Distance = 600 pc
- Luminosity = 3300 Lsolar
- Radius (primary) = 45 Rsolar
- Temperature = 6500 K
- Mdot = 1e-8 Msolar/yr
- Large IR excess suggests dust shell.
- Negligible extension suggests disk geometry for dust.
- 89 Her apparent diameter is 0.7 mas; predicted $V^2 =$ at 2.2 μm.

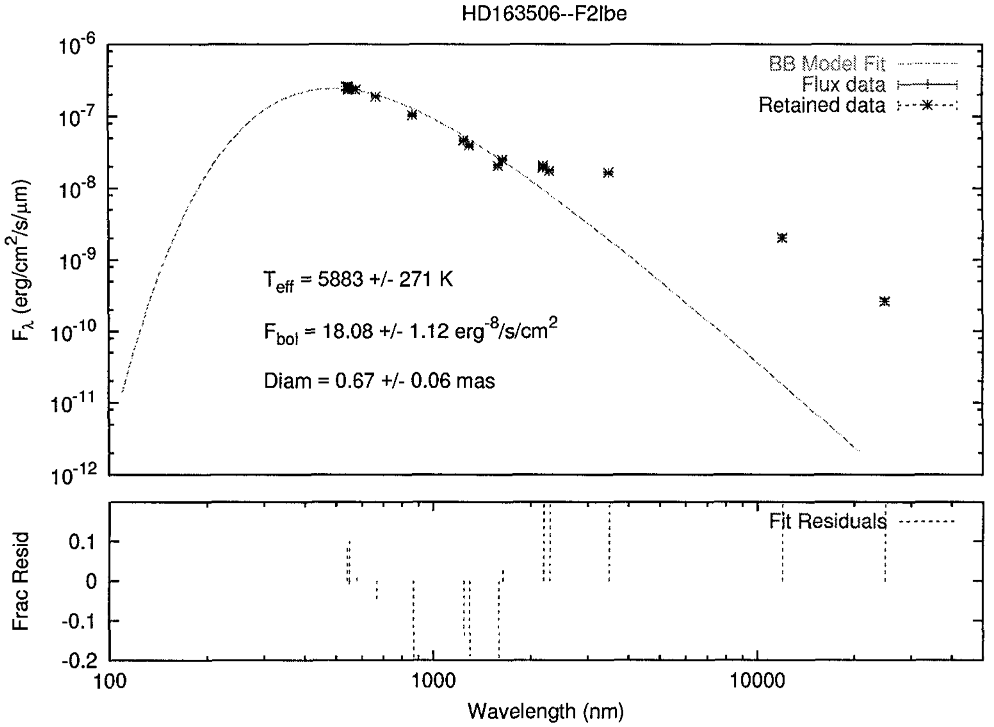

Figure 1: Photometry for 89Her showing the IR excess. Separate short and long wavelength fits to the data come up with a stellar temperature of about 5850 K and a dust temperature of about 1100 K.

3 The Observations

Day #	scans	start	stop	V^2	jitter (rads)	WL/spec DN	avg lock brakes
99126	15	9:10	9:57	0.044/0.053	0.507	617.3/37.9	0.53
99144	10	9:35	10:16	0.047/0.055	0.958	568.3/34.5	2.1
99177	9	7:31	8:33	0.050/0.053	1.641	1333./105.	4.22
99178	5	7:32	9:04	0.026/0.059	1.782	1461./77.3	8.2
99239	20	3:08	4:56	0.046/0.054	0.794	1385./57.0	0.3
100123	2	11:29	11:31	0.043/0.046	0.665	1880./73.5	18
100130	1	11:24	11:24	0.037/0.037	0.48	902.1/42.1	17
100140	32	9:48	12:14	0.148/0.296	0.942	448.4/9.34	17.5
100154	5	10:42	10:49	0.049/0.060	0.732	1470./38.2	10.4
100159	12	6:51	7:20	0.022/0.425	0.84	419.2/5.70	14.5
100164	5	9:12	10:32	0.039/0.046	0.936	1617./67.2	12.6
101128	20	10:21	12:07	0.198/0.243	1.01	795.6/19.1	15

Table 1: Summary of PTI observations of 89 Her.

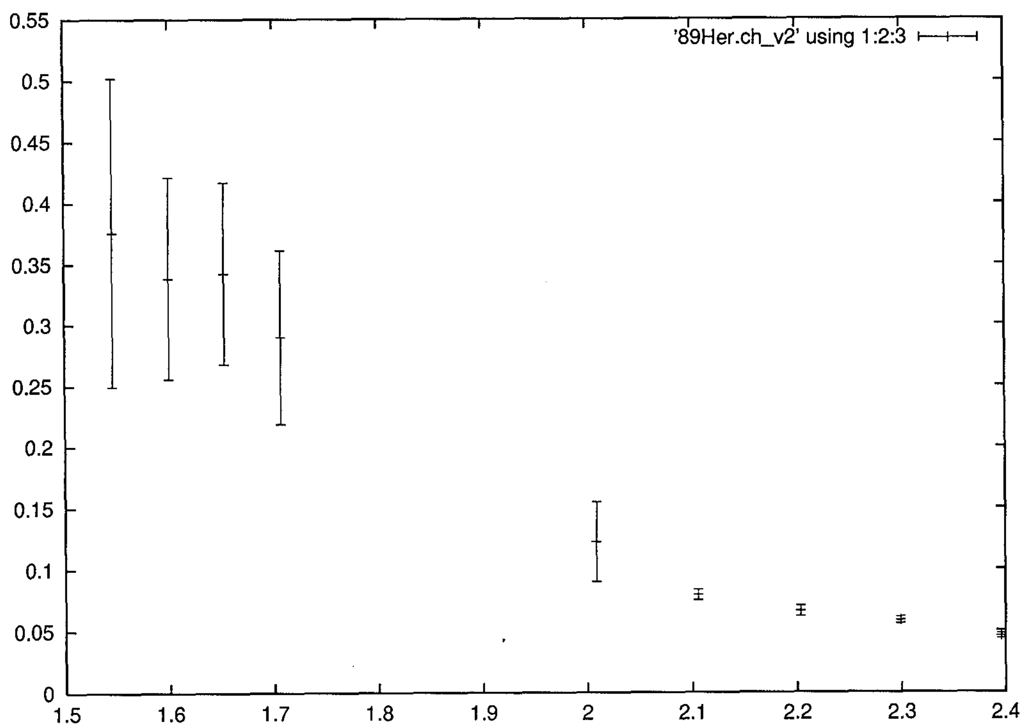

Figure 2: Visibility data as a function of wavelength (microns) for the H and K bands.

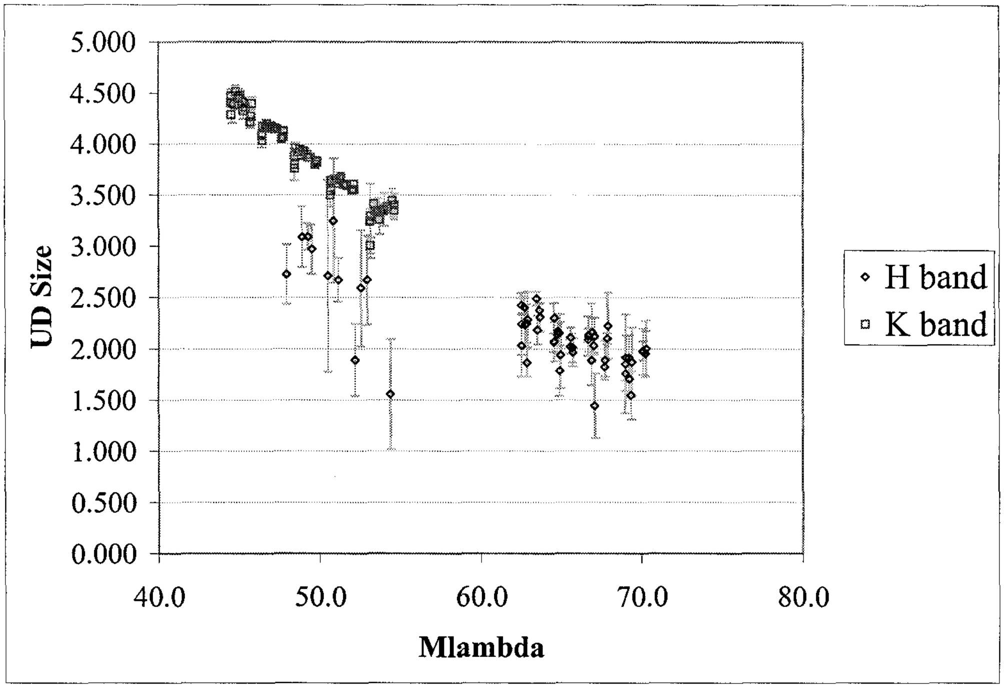

Figure 3: Uniform disk diameter inferred from the H and K band data as a function of baseline length.

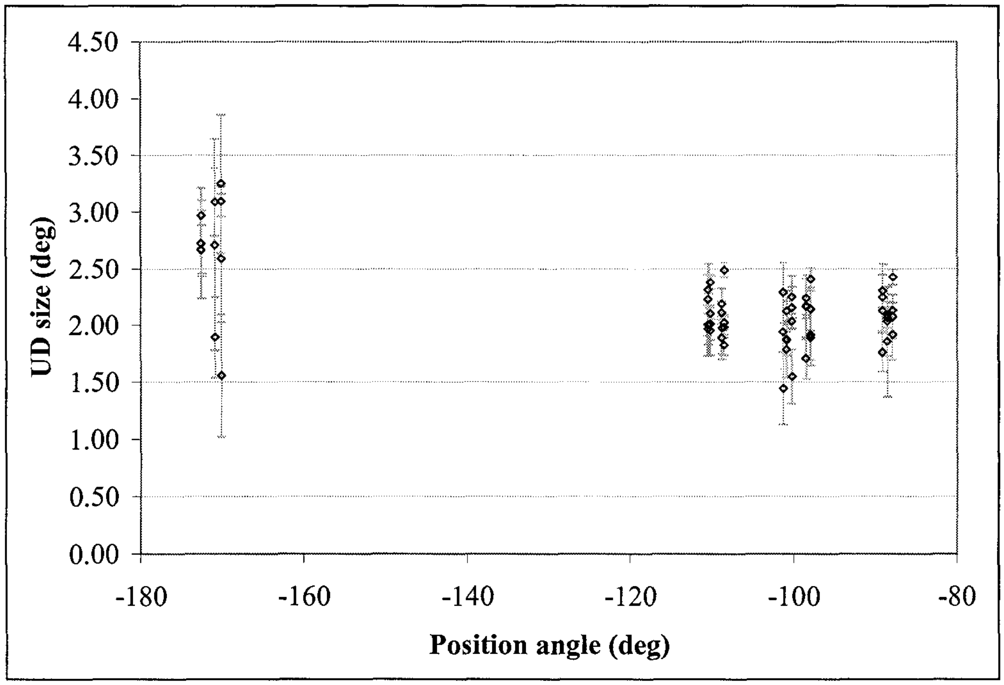

Figure 4: Uniform disk diameter inferred from the H band data as a function of baseline position angle.

4 Can a Binary Produce the Observed V^2?

- Binary orbital solution reported for this system (Walters).
- Probable secondary mass given as 0.09 to 0.07 Msolar.
- If primary and secondary are equal (0.5 Msolar), R/a = 0.44.
- Intensity dynamic range of PTI implies Lsecondary $geqLprimary/30$ for the binary V^2 to be detected.
- Thus only similar mass and evolutionary stage binary companion could be detected by PTI.
- Binary test case is Mprimary = Msecondary, Lprimary = Lsecondary, separation is 2.1 mas.

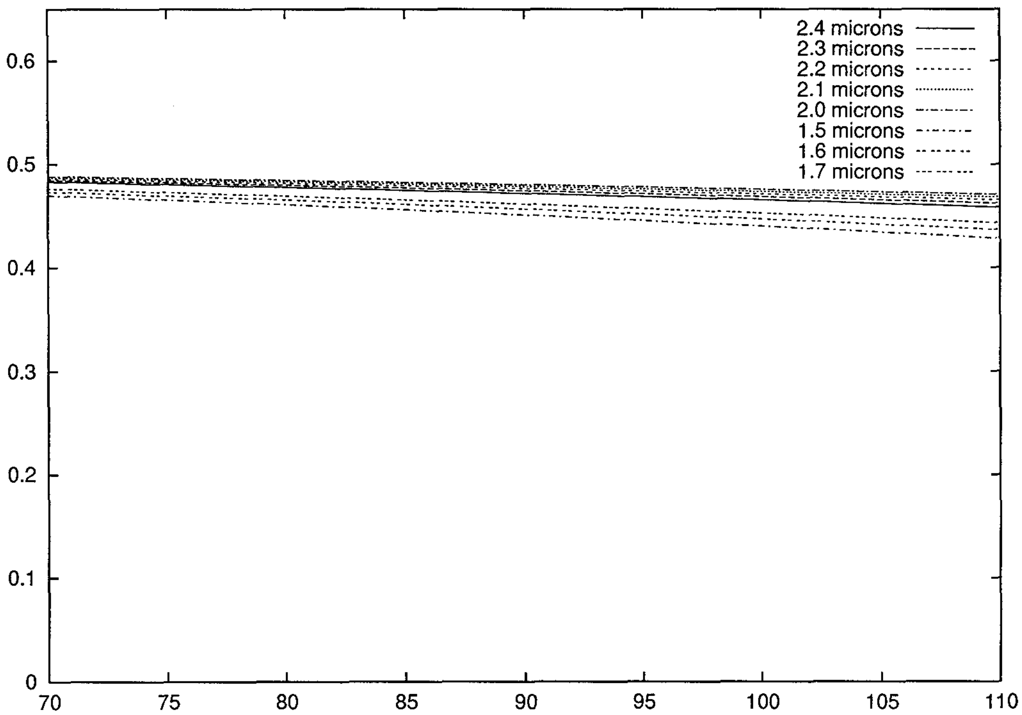

Figure 5: An estimate of the maximum chromatic V^2 effect due to a possible binary companion to 89 Her. For this we have assumed the most extreme possible case for a binary companion; a secondary of identical mass and luminosity. The result produces a chromatic V^2 substantially different than our observations. This suggests our observations are caused by another effect.

5 Signature of the Dust Disk

- Assuming $T \sim 1/r^2$ from a 6500 K stellar surface until the onset of dust formation, $\sim$ 1000 K dust forms at a radius of about 2.6 Rstar (0.9 miliarcsecons).
- The combined V^2 of star plus dust is:

$$V^2_{total} = \frac{F_{star}V^2_{star} + F_{dust}V^2_{dust}}{(F_{star} + F_{dust})^2}$$

- Solving for $V(2)_{dust}$ we find corrections to the observed V^2 are small due to the simultaneous constraints of the ratio of dust emission to star emission, baseline evolution of the H band data, and size scale of the dust emission.

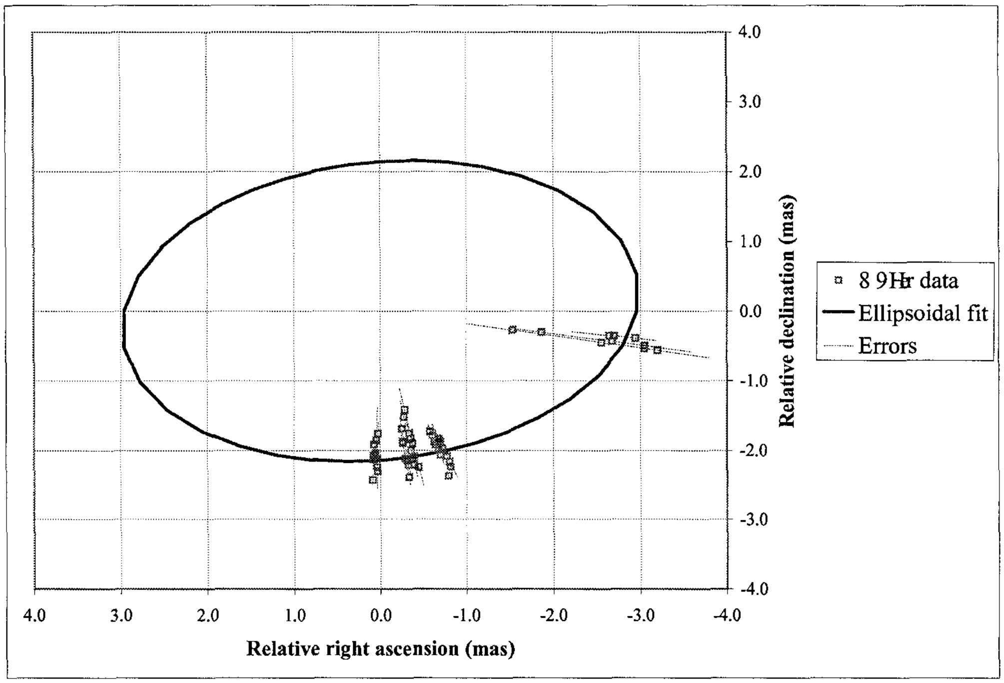

Figure 6: An ellipse fitted to the H band data. This suggests an disk rotation axis is inclined to the line of sight of about 25 degrees. The total V^2 have been used in this plot. Corrections for the stellar component could change the size of the disk but not the ellipticity.

V^2_{total}	r=.1	r=.2	r=.4	r=.6	r=.8	r=1.0	r=2.0	r=4	r=6	r=8	r=10
0.05	-9.40	-4.64	-2.26	-1.45	-1.05	-0.80	-0.28	**0.06**	**00.24**	**0.38**	**0.51**
0.10	-8.79	-4.28	-2.01	-1.24	-0.85	-0.60	-0.05	**0.38**	**0.65**	**0.89**	1.11
0.15	-8.19	-3.92	-1.77	-1.03	-0.64	-0.40	**0.18**	**0.69**	1.06	1.39	1.72
0.20	-7.58	-3.56	-1.52	-0.81	-0.44	-0.20	**0.40**	**1.00**	1.47	1.90	2.32
0.25	-6.98	-3.20	-1.28	-0.60	-0.24	**0.00**	**0.63**	1.31	1.88	2.41	2.93
0.30	-6.37	-2.84	-1.03	-0.39	-0.04	**0.20**	**0.85**	1.63	2.28	2.91	3.53
0.35	-5.77	-2.48	-0.79	-0.17	**0.17**	**0.40**	1.08	1.94	2.69	3.42	4.14
0.40	-5.16	-2.12	-0.54	**0.04**	**0.37**	**0.60**	1.30	2.25	3.10	3.93	4.74
0.45	-4.56	-1.76	-0.30	**0.25**	**0.57**	**0.80**	1.53	2.56	3.51	4.43	5.35
0.50	-3.95	-1.40	-0.05	**0.47**	**0.78**	**1.00**	1.75	2.88	3.92	4.94	5.95
0.55	-3.34	-1.04	**0.20**	**0.68**	**0.98**	1.20	1.98	3.19	4.33	5.44	6.56

Table 2: Permitted values of dust V^2 show in bold for a range of flux ratios between the disk and the star (r=Fdisk/Fstar) and total V^2.

6 Conclusions

- We have directly detected the warm dust component around 89 Her.
- There is an indication that the dust distribution is not rotationally symmetric.
- We infer a disk orientation of approximately 25 degrees out of the plane of the sky; better $u - v$ coverage would significantly improve this constraint.
- If the disk and binary system share an angular momentum axis, then the secondary would be well within the accepted radius of the primary.
- The secondary, if it exists, probably plays an important roll in suppling material to the disk.

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